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General Consideration on a Soil Survey of Malaya.

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Most progressive countries during the last three decades have undertaken some form of soil survey with the idea of facilitating agricultural practice by ascertaining the distribution of different kinds of soil and, by utilising previous experience, of predicting the parts of the country most likely to be suited to various crops and the soil treatments likely to give the best results with each crop.

It will readily be realised that the actual nature of the soil at any particular spot is not the only factor involved, climate and topography playing very large parts from the agricultural standpoint. It is an easy, although a time-consuming task, to describe the soils of any area in terms of some particular character, such as physical composition (proportions of particles of different sizes) or chemical composition but trouble is at once encountered when an attempt is made to group soils, i.e. to classify them. What basis should be chosen, and should it deal with intrinsic properties or with genetic relationships? It is agreed that no one stratum of the soil nor character can entirely be relied on, and a selection must be made from a number of characters.

The earlier surveys, especially those in the United States, started with classification based on geological origin, as it is reasonable to suppose that soils formed from similar rocks should be similar in many respects. As the surveys extended

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however it was found that these relationships did not hold, similar parent material producing widely different soils under different climatic conditions. Recently the very active Russian workers have classified soils on the basis of climate and have shown that, subject to certain limitations, similar climates tend to produce similar soils irrespective of geological origin.

Until recently no systematic soil work had been carried out in Malaya and when a definite Soils Division was constituted the most pressing task appeared to be that of classification; especially in view of the impracticability within any reasonable time of a detailed soil survey of the whole area of Malaya. If a satisfactory classification of soils on easily accessible areas could be devised it might then be possible approximately to predict the soil characteristics of larger inaccessible areas, due regard being paid to modifications due to topography.

In spite of the failure of geological classifications in the U.S.A. it seemed not improbable that when dealing with the relatively very small area of Malaya over which the climatic conditions (from the soil-forming standpoint) are uniform, such a basis might be useful, as very considerable areas of Malaya have been dealt with by the Geological Survey and the results given on the "Geological Sketch Map of Malaya". To test this a detailed survey was carried out over a limited and accessible area. The results of physical analyses of the samples collected are described in the succeeding paper.

It is believed that the results of this preliminary survey show that the inland soil (i.e. those formed *in situ* or nearly so) can broadly be grouped on a geological basis, climatic factors having, as anticipated, acted uniformly.

To verify the suggested grouping, it will be necessary to carry out analyses on different areas throughout the country. At present we have outside the surveyed areas only a limited number of samples taken for other purposes. These as far as they go, confirm our conclusions. It has been decided that this work of checking must await the completion of detailed work on the difficult problem of the coastal alluvial soils, and it is thought that the results already obtained, which might be of some help to planters, should be published, with full reservation of liberty to change the suggested classification should further work indicate the desirability of such a step.

In view of the limited scope of the succeeding article reference to chemical analyses and the place of our soils in a world-scheme of classification has been omitted. These and other points will be taken up later when a comprehensive discussion of Malayan soils is published.

Assuming that the classification put forward is correct we have next to enquire in what way the work may benefit agriculturists. We are immediately faced with a difficulty already set forth by the writer* viz. that there exists no fund of previous experience with any inland dry land crop except rubber. This at once limits us to the simplest deductions, those based on mechanical composition. Information regarding manuring and soil treatment generally will only be available after considerable experimental field work with different crops on the various soil types.

With regard to mechanical composition we learn from the tables and figures in the succeeding article that of the *high level soils* (i.e. soils above valley level):—

1. The "Raub" soils are far more uniform in texture than the other two groups, which show considerable variation in the clay/sand ratio. Once topography is known the texture of any area of "Raub" soil may therefore be assumed with but little sampling.
2. Owing to the fairly general occurrence of gravel and stones, soils of the "Raub" and "Granite" groups have a more open texture than the "quartzites" which even when sandy "pack" badly on exposure.
3. Erosion is always serious but an amount of erosion which will deteriorate a "quartzite" with its deep and rather uniform profile may absolutely ruin a "Granite" or "Raub" by washing away the highly differentiated top soil and leaving only a stony subsoil or indeed bare rock. Cases of such damage have actually occurred.

Of the *low level soils* (valley soils) it emerges that the "quartzites" are far more likely to exhibit undesirable features such as shales, black soil etc. than are the other two, and therefore need careful prospecting.

* Annual Report for 1927. This Journal XVI, p. 170 '28.

In conclusion the writer desires to emphasise the provisional nature of the classification adopted, and also to point out that none of the soils dealt with are "rich" in the sense of giving on analysis high figures for nutrients even in the virgin state. There are one or two geological formations such as the "Pahang Volcanic Series" which when near the surface may produce "rich" soils, but they have not yet been surveyed, and in any case are of limited distribution, compared to the three groups discussed here. No soil in the tropics should however be condemned on the grounds of "poverty" alone, rubber furnishing an excellent example of a crop which flourishes exceedingly on extremely "poor" soils.

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Preliminary Results of a Soil Survey in Selangor.

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In the previous paper it was suggested that in spite of the failure of a classification of soils on a purely geological basis in the U.S.A. owing to the climatic conditions, yet in this country where climatic conditions are more or less uniform, such a basis might be useful and it was with this idea in view that a detailed survey over a restricted area was carried out.

The factor determining the area over which the survey was made, was, in the first place accessibility, this being regarded as of paramount importance for rapidity of work. The second point was that the area should pass through the main geological formations.

For these reasons the area chosen was one stretching through Cheras and Klang to the sea, thus including the four main geological types and further including the Experimental Plantation of Serdang and Ayer Hitam Forest Reserve, the former being examined completely in detail and the latter in detail near the road frontage.

The four main geological types mentioned above are:—

- (a) Limestones and calcareous shales, phyllites without sandy beds which may be referred to collectively as the Raub series.
- (b) Quartzites, including sandstones, shales and certain phyllites which may be altered to schists near granite.
- (c) Granite.
- (d) Coast alluvium.

The vast majority of the area of Malaya which has been geologically surveyed has been shewn to consist of one of these formations. There are three additional geological types with which it is not proposed to deal here as the areas which

they cover are comparatively small and are not to be encountered in the country over which the soil survey was carried out.

The oldest formation is the Limestones etc (a). They were deposited on the sea floor in Palaeozoic times far from land, beyond the reach of sediment brought down to the sea by rivers.

Later shallow water conditions set in and alluvium was brought down by the rivers which in the course of time under pressure became altered to quartzites and sandstones. Where this alluvium was in contact with limestone calcareous shales were formed.

At a later date, the granite and allied rocks which now form the backbone of the peninsula, forced their way up through the earlier formations.

Lastly the coastal alluvium, which although its age runs into millions of years is geologically modern has been gradually formed by the erosions of the older formations, the sediments of which have been deposited on the sea floor by the rivers.

This briefly and in a very elementary way represents, in the main, the formation of these four types. Calcium has been gradually leached out of the calcareous shales until at the present time the overlying soils seem to be little or no richer in calcium than any other soils.

High level alluviums have been formed in parts by the erosion of granites and quartzites and have apparently been deposited in many cases over limestone. Inland alluvium is still being formed at the present day and is discussed further in connection with soils as found in the survey.

SURVEY RESULTS.

Sampling was carried out on the soil overlying each of the geological formations, detailed at first, the distance apart of sampling increasing as information was obtained about the different types of soils.

It may now be stated that as a result of this survey it is concluded, at least as far as the area surveyed is concerned that there is a distinct soil type for each of the four formations mentioned above.

The soil overlying the alluvium however is not dealt with here, as the whole of the coastal alluvium is likely to prove much more complex than the inland formations and requires separate consideration. The soils overlying the other three formations will be referred to in the rest of this article as

- (a) Raub family.
- (b) Quartzites.
- (c) Granites.

The reason for so naming these soils will be made clear below, though it must be stated that these names are purely tentative, and they may have to undergo certain modifications as further information becomes available.

The general features observed were :—

(a) THE RAUB FAMILY.

The soils under this heading may be divided into two parts "soils above plain level" and "plain soils", or more shortly "high level" and "low level" soils. The former might be further subdivided into "hill top soils" (including very steep slopes) and "general above plain level".

(i) *High Level.*

The distinctive features of the soils above plain level is the appearance of hard "laterite"* beds at a depth of from eighteen to thirty inches generally, but which may be right at the surface where land has been subjected to heavy wash (hill tops and steep slopes) or may, where conditions have caused an accumulation of soil on top, be some feet below the surface. They are in fact the soils which are commonly known locally as laterite soils, a name which it is better to avoid as a soil description owing to the controversy as to the correct use of the term.

These beds are always deep enough to resist much penetration by a sampling tool in contra distinction to quartzites, where "laterite" may occur but usually only as a thin layer.

It seems probable that these beds are a layer of accumulation of ferruginous material leached out from the soils above.

*Laterite is here used in its local popular sense rather than as a strictly scientific term.

The overlying soil is always of a redder colour than the quartzites except where swamp and waterlogged conditions have existed, when it may be reduced to a pale yellow.

The soil above the laterite bed usually shews a good crumb structure and does not have that tendency to "pack" exhibited by the quartzite. It is usual to find over 45 per cent of clay in the surface soil, in fact there is less variation in the clay of this type than in any of the others as will be seen from the correlation tables which are discussed below.

In the lower layers the analysis of soil passing the 3 mm. sieve is deceptive as out of the total original soil as much as 75 per cent stones may be found by the time a depth of two and a half to three feet is reached. This is also brought out in the tables. The total sand at any depth is generally not above 25 to 30 per cent, the bulk of the coarse fractions being classed as gravel.

(ii) *Low Level.*

These soils would appear to be of the nature of a high level alluvium, probably overlying a limestone floor. No soils of this type occur in the survey area, but an excellent example may be seen on the road from Setapak towards Klang Gates and for the first few miles along Batu Road from Kuala Lumpur to Batu. The distinguishing features of the areas on which these soils occur may be said to be their flat open nature. The soils are usually whitish yellow in colour occasionally mottled and show a fairly open texture and crumb structure. They frequently "feel heavier" than their mechanical analyses would lead one to suppose which may be accounted for by the necessarily artificial nature of their drainage. They do not appear shaly as the quartzite valley soils neither do they shew the darkening which is such a distinctive feature of the latter.

(b) QUARTZITES.

The quartzite soils also may be divided into two groups (i) Valley Quartzites and (ii) General Quartzites, but owing to a much more intimate relationship holding between them than in the case of the two groups of the Raub family, they are here considered as a whole.

This is probably the soil most commonly met with agriculturally in this country, though its actual area is considerably less than the granite, which covers the main range

of the peninsula; quartzite on the West side of the main range covers large tracts of undulating land which have been agriculturally exploited.

Its colour is usually a brownish orange. This colour does not differ greatly from that of granite, though on an average it is probably rather "brighter". The soils around the Agricultural Department are typical of the quartzite. The mechanical composition seems to show much more variation than the granite, the clay for instance on undulating ground may vary from 15-45 per cent and generally speaking the soils contain a fair quantity of silt. This type of soil has a tendency to "pack" and its crumb structure is considerably less than that of Granite or Laterite.

Owing to the softer nature of the parent material there seems a tendency for the quartzite valleys to be much broader than the granites and for heavy shaly formation to occur there. One of the peculiar features of this heavy shaly formation is the frequent inclusion of organic matter in a very finely divided state, which on extremely heavy clays (fine fractions of the order of 70 per cent and over) is often present as free carbon, the soils being jet black when they are wet. Generally such dead black soils are modified at the surface and appear as a brownish black. These black soils seem to have definitely toxic effects on plant life due probably to ferrous iron compounds including iron pyrites. It is suggested that these (black) soils are formed by swamp conditions and from observations made at Serdang it seems likely that they generally ensue at what may be described as the centre of a swamp drainage area. Often a curiously impervious sandy bed is encountered in broad quartzite valleys and plains at a depth varying from four to six feet.

On the other hand as in the cases of the granites, where quartzite valleys do approximate to the gorge type, the soil is usually more sandy than the surrounding land due no doubt to the clay being swirled away and deposited in more open areas during heavy rain.

A still further feature is the frequent occurrence, at depths which may vary between eighteen inches and over six feet, of a thin layer of "laterite" often accompanied or sometimes entirely replaced by quartz chips up to an inch across. This layer is generally not very compact and of only an inch or so in thickness and is fairly easily gone through. It would

seem to be a layer of accumulation between the upper weathered rock in the form of soil and the schist formations below. Leaching of the soil above appears to have freed much ferruginous material which has accumulated at the layer of separation of the schists and soil, with the formation of "laterite." This has been mentioned above under Raub family soils.

(c) GRANITE.

A soil which may vary from a pale yellow to a red in colour and generally approximately to a bright yellow. On undulating land it is a friable soil composed of sands and clay with little or no silt. A typical analysis of such a soil would be clay 40—50, silt 0—5, sand and gravel 55—45. In cases where broad valleys are filled with soil from hillsides there is a considerable increase in the silt content and a diminution of sand but in cases where valleys between hills approximate to gorges the reverse is the case there being a considerable decrease in the clay and increase in the sand.

The valley clay soils are friable. At the junction of granite with neighbouring formations the soils may present an unusual appearance, soils on the Kajang—Puchong road for example near the Raub family junction shewed kaolin; on the other hand on the Klang Road there is a sharp change from normal granite soils to normal quartzite.

CORRELATION.

The general mechanical relationships have been brought out by means of the correlation tables and graphs given at the end of this article.

From these tables it will be observed that:—

- (i) Exclusive of hill tops and very steep slopes and above plain level the Raub family soils shew a great evenness in the percentage of clay at the surface, all of them shewing clay in the 46—60 group (Table I) while the sand and gravel for the most part lies in 31—45 group. From Table II it will be seen that fifty per cent of these soils contain up to 15% stones at the surface.

From Table I again it will be seen that the clay content is reduced some 15% at a depth of 30" for about eighty per

cent of the soils and even as much as 30% for the remaining twenty per cent. From Table II it will be noticed that none of these soils contain less than 16% stones at a depth of 30". Fifty per cent of them contain 16—30 at this depth, twenty per cent contain 31—45% and thirty per cent of them contain over 60 per cent of stones.

These stones all bright red in colour and which may be loosely described as laterite are sufficient in themselves to differentiate the soils from any others.

- (ii) In the quartzite valley soils the clay is evenly distributed for the most part through a considerable range of percentages (eighty-six per cent lying between 16 and 60%) the sand also shewing a wide range (seventy three per cent evenly distributed from 31% of sand upwards). At a depth of 30" there is no change in the clay distribution but somewhat of an increase in the percentage of soils shewing sand 46—60%.
- (iii) In general quartzite soils, over fifty per cent of them have a clay content of 31—45 at the surface and that nearly sixty per cent of them have a sand content of 46—60. There is little change in this composition at 30".

From Table II it will be seen that some ten per cent of quartzite soils contain up to 15% of stones at a depth of 30" and eight per cent contain even more.

- (iv) Over forty four per cent of the granite soils have a clay content at the surface of 31—45 and forty per cent have a sand content of 46—60. At a depth of 30" forty per cent have the above clay content, with a tendency for the clay content to increase, while fifty-eight per cent have a sand content between 16—30%.
- (v) The figures indicated above are not in themselves sufficient to differentiate the granites and quartzites, but an examination of gravel contents shows marked differences between them. From Table III it will be seen that whereas only half the granites shew a gravel content 0—15, ninety eight per cent of the quartzites fall within these limits and at a depth of 30" rather less than half the granites and eighty

seven per cent of the quartzites shew a gravel content of less than fifteen per cent.

The difference is even more strikingly shewn in Table IV when it will be seen that whereas only sixteen per cent. of the granites have a gravel content of less than 4%, eighty-five per cent of the quartzites fall within this category.

The larger gravel content met with in the granite soils seems to account for the marked open structure which they shew.

AGREEMENT OF THE SOIL TYPES AS OUTLINED ABOVE WITH THE GEOLOGICAL BOUNDARIES.

It has been stated above that the three soil types (a) Raub family, (b) Quartzite, (c) Granite sketched above are found overlying the respective geological formations (a), (b) and (c). The question immediately arises in the mind that assuming a certain type of soil described as granite, is found overlying a granite geological formation, will this type of soil disappear and the "laterite" type appear as one passes over the geological junction from the granite to the "Raub Series". This may be answered in the affirmative as far as the area under survey is concerned. In many places the cleavage is sharp, as on the railway from Kajang to Kuala Lumpur, where in a cutting between the 257th and 258th mile it is possible to see the geological change over from granite to Raub series and by sampling to confirm the change over of soils. In other places it is impossible owing to the deep swamp nature of the soil to find the change over. In cases, the soil change over may not agree precisely with the geological change over owing to topographical conditions. For instance suppose that the junction of a granite and quartzite formation occurs on a hill side, the granite being situated higher up the hill. Then one would naturally expect to find a certain amount of granite soil on the quartzite side of the junction.

The indications as set forth in this paper are of course empirical and are founded on the area actually surveyed. It may be that "spot" examination in other parts of the peninsula may cause a certain amount of modification of what has been written above, though casual soil samples which have been received in connection with other problems from Johore, Pahang and Negri Sembilan confirm the above conclusions.

A striking confirmation of soil type agreeing with geological formations must have been noticed by anyone travelling along the Port Dickson road which from Seremban to Port Dickson lies entirely over the "Raub Series" geological formations (coloured blue on the geological sketch Map). The untrained eye may not be able to recognise the features which indicate the geology (which may be assumed to be correct) but one can hardly fail to recognise the distinctive soil features indicated above under the heading Raub family, wherever the land is undulating or silt pitted.

Particular thanks are due to Mr. J. B. Scrivenor, the Director of Geological Surveys for the valuable help he has given in this connection.

A geological sketch map of Malaya is appended, taken from the Geological Department's progress map. It may be subject to slight modifications but as a whole it represents the geology of the country as surveyed up to the present time. It is hoped that in conjunction with the above article it may be of some assistance in providing a broad differentiation between the main inland soils.

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TABLE I.
PERCENTAGES SOILS SHOWING VARYING % OF CLAYS AND SANDS
WITH GRAVEL AT SURFACE AND AT 2 FT. 6 INS.

Clay % Sands and Gravel %		Under 15		16--30		31--45		46--60		61 and over	
Soil		At Surface	At 30"	At Surface	At 30"	At Surface	At 30"	At Surface	At 30"	At Surface	At 30"
Granite	C ...	0	20	34	20	46	40	24	30	6	10
	S ...	8	8	4	58	24	20	40	10	24	4
Raub Family Excluding Hill Tops (high level)	C* ...	0	0	0	20	0	80	100	0	0	0
	S ...	0	50	0	50	80	0	20	0	0	0
Raub Family (Low level)	C* ...	12	0	75	75	13	25	0	0	0	0
	S ...	0	0	13	12	25	25	25	63	37	0
Quartzite Valley	C ...	5	4	28	29	33	36	25	22	9	9
	S ...	13	9	14	14	25	18	23	35	25	24
Quartzite General	C ...	4	0	26	28	54	53	16	19	0	0
	S ...	0	0	2	4	14	13	58	62	26	21

* Table based on analysis of some 20 soils only. Visual inspection confirms these figures.

TABLE II.
PERCENTAGES SOILS SHEWING VARYING % OF STONES AT SURFACE
AND AT 2 FT. 6 INS. (ON ORIGINAL SOIL).

Stones %	0-15		16-30		31-45		46-60		61 and over	
Soil	At Surface	At 30"	At Surface	At 30"	At Surface	At 30"	At Surface	At 30"	At Surface	At 30"
Granite	0	16	0	0	0	0	0	0	0	0
Raub Family Excluding Hill Tops, but all above plain level.	50	0	0	50	0	20	0	0	0	30
Quartzites	0	10	0	6	0	2	0	0	0	0

TABLE III.
 PERCENTAGES SOILS SHOWING VARYING % COARSE SAND AND
 GRAVEL AT SURFACE AND AT 2 FT. 6 INS.

Coarse Sand % Gravel %		0—15		16-30		31-45		46-60		61 and over.	
Soil		At Surface	At 30"	At Surface	At 30"	At Surface	At 30"	At Surface	At 30"	At Surface	At 30"
Granite	C. S.	24	24	60	60	16	16	0	0	0	0
	Gravel	48	44	48	48	4	8	0	0	0	0
Quartzite	C. S.	5	10	52	54	31	28	8	6	4	2
	Gravel	98	87	2	5	0	8	0	0	0	0

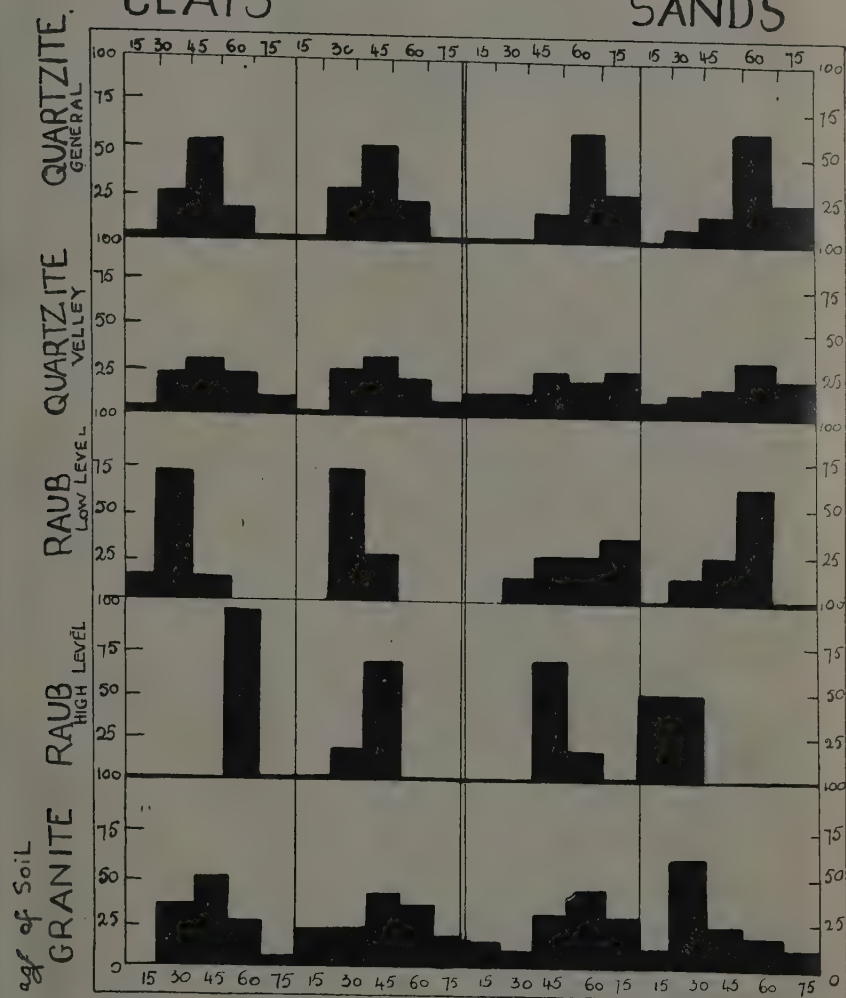
TABLE IV.
PERCENTAGES SOILS SHOWING VARYING % GRAVEL
AT SURFACE AND AT 2 FT. 6 INS.

Gravel %		0-4		5-8		9-16		17-24		24 and over	
Soil		At Surface	At 30"	At Surface	At 30"	At Surface	At 30"	At Surface	At 30"	At Surface	At 30"
Granite	...	16	12	16	20	28	24	32	20	8	24
Quartzite	...	85	65	5	8	10	14	0	2	0	11

TABLE I.

CLAYS

SANDS



page of CLAYS

AT SURFACE

AT 30'

page of SANDS

AT SURFACE

AT 30'

TABLE II.

STONES

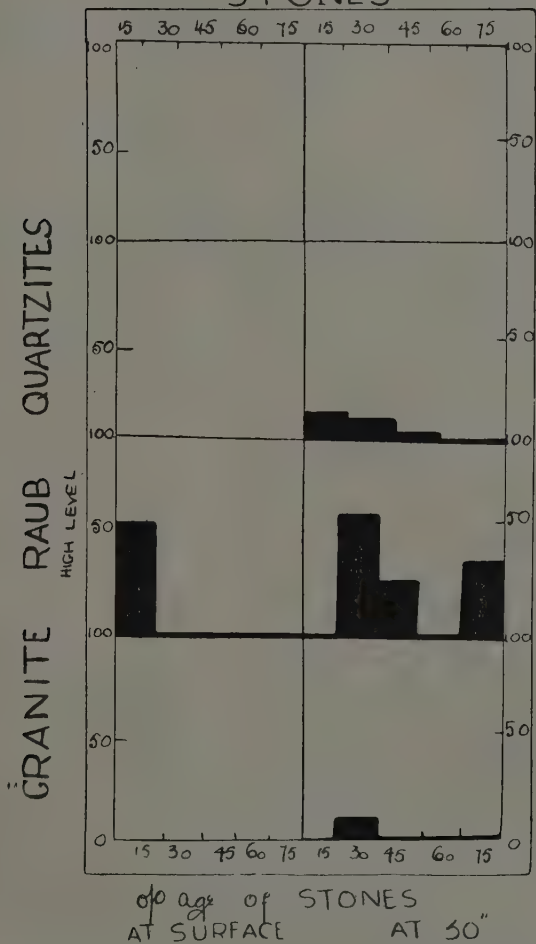


TABLE III.

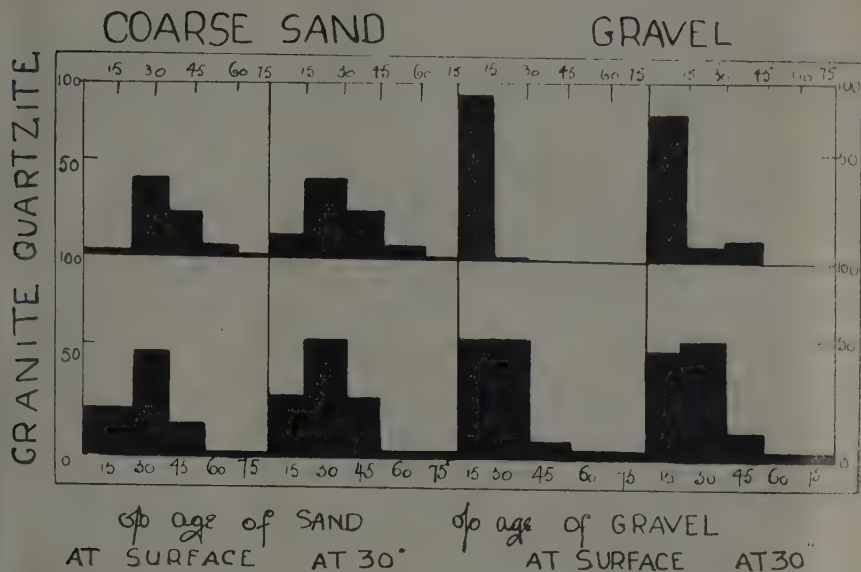
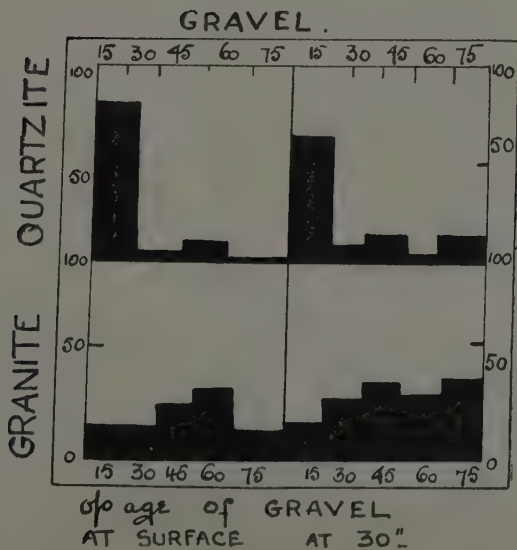


TABLE IV.





Percolation Experiments.

I. NITRIFICATION AND EFFECT OF COVER PLANTS

BY

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Considerable inequalities having been found in certain nitrification experiments, it was decided to set up a series of percolation experiments to test nitrogen losses as indices of nitrification. The same lay-out was then used for observations of nitrogen losses under covers. These observations are still in progress, but the results obtained up to date may be of some interest and are accordingly published.

LAY-OUT OF EXPERIMENTS.

Cylindrical glazed earthenware pots 17" high and 11½" internal diameter holding 25—28 kilos (56—62 lbs.) of moist soil were used. Drainage water was led through tubulures into covered receptacles.

The pots were filled with earth at field moisture (about 20%) taken at a depth of 1—6" and after the treatments set forth in Table I, were left bare and fully exposed to the weather. Analyses were made whenever 800 ccs. or more of percolate had collected. The year 1928 was marked by prolonged dry spells which accounts for the relative infrequency of analytical results. Soil "A" was a sandy "quartzite"* soil from a slope which had been clean weeded under rubber and oil palm for many years. It had suffered considerably from erosion and the clay was highly deflocculated, as a result the percolates were frequently very cloudy and required filtration. Like all soils of this group it is very prone to

* For an explanation of these terms vide M. A. J. this issue page 181 et seq.

"pack" badly. The pH of 1:2 suspension with quinhydrone was 4.9, N as nitrate less than 1 part per million, and lime requirement (by calcium acetate) 1.6 tons per acre (CaO). Soil "B" was what is called locally a "laterite" soil—one of the "Raub family, high level" soils.* It had been under "lallang" (*Imperata arundinacea*) for an indefinite period, was of fair crumb structure and always gave clear percolates. pH=4.4; N as NO_3 4 p.p.m., lime requirement 2.2 tons per acre.

TABLE I.

The differences in volume of percolate collected from the different pots illustrate the extreme difficulty of securing uniform packing. These differences do not however obscure certain facts:—

- (1) That nitrification of all fertilisers proceeded normally.
- (2) That there was a considerable increase of nitrate losses from soil left fallow even though no nitrogenous manures had been added.
- (3) That the acidity (indicated by a *low* pH value) of percolates increased with increasing nitrate content.

TABLE II.

It has frequently been demonstrated that the growth of plants reduces drainage losses to a very great extent. It must however be remembered that where cover plants with superficial roots are growing with main crops which may be deeper rooted—the drainage losses found under the conditions of our experiment are, as far as nitrates are concerned, the plant food of the main crop plant, since nitrates are formed only in surface soil. In view of the normally low concentrations of nitrates in our soil, it is clear that rapid absorption by the cover might tend towards nitrogen starvation of the main crop. It was therefore decided to try the effect of cover plants. For the first cover a grass crop was chosen, both because of vigorous growth and also because

* vide M.A.J. this issue page 181 et seq.

grasses are known to have a deleterious effect on many fruit trees.

The results show clearly:—

- (a) That the nitrate in percolates from grassed plots was reduced practically to zero.
- (b) That there was a decrease in acidity coinciding with a fall of nitrates.

TABLE III.

The next step was to plant a cover other than grass, for this purpose *Calapogonium mucunoides* was selected. This plant gave irregular growth, but again especially on soil "B" the results show a great reduction of nitrates in the percolate wherever good growth was made.

The all-round reduction is due to the heavy leaching experienced by the soils in the very heavy March-April rains of this year.

CONCLUSIONS.

Fallow and covers.

It is impossible on the results of these experiments by themselves to give definite advice for use in the field—but two points appear to emerge:—

- (a) That land left fallow will suffer considerable losses by leaching downwards of the product of nitrification. This confirms the abundant experience of other countries.
- (b) That the distance of covers from the main crop especially when that crop is in early stages should carefully be considered, lest the cover starve the main crop of nitrogen. This applies particularly to the growth of permanent covers.

Acidity and nitrate development.

As far as the relationship between acidity and nitrate content goes, the results of tables I and II strongly support the view previously expressed by the writer that the dis-

crepancy between pH values observed on suspensions and in clear extracts of many of our soils is due to the very low concentration of the soil solutions—which do not contain sufficient quantities of anions to carry hydrogen ions out of the field of action of the soil particles. The results in table III however are puzzling, since the only differences in treatment of the bare pots in this experiment was that during dry weather the pots were watered. This would suggest the rather incredible hypothesis that nitric acid formed in nitrification could be neutralised by the small quantities of bases in the soil only if the amount of moisture exceeded a certain critical value. Further observations on this point are in progress and will be reported in due course.

SUMMARY.

Observations are reported on the nitrogen losses from soils under covers, bare and enriched by nitrogenous fertilisers.

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TABLE I.

SOIL INTO POTS ON 29.11.27, PERCOLATE UP TO 14.12.27
BULKED. TREATMENTS APPLIED ON 16.12.27.

Soil "A."

Pot No.		30/12/27	6/2/28	9/2	22/3	6/4	13/4	18/5	Average N. as mgs. per litre.
1. Lime = $\frac{1}{4}$ ton per acre -	pH percolate Vol. percolate (litres) N. parts per million as NO_3	6.2 2.0 1	5.9 1.8 trace	4.2 4.0 7.0	4.8 1.0 28	4.2 1.3 27	4.7 2.75 40	4.2 .8 31	18
2. Lime = $\frac{3}{4}$ ton -	do.	6.2 2 0.4	6.4 2.5 trace	4.2 4.0 7	4.5 1.15 50	4.2 .9 33	4.3 2.75 40	4.2 .70 29	18
3. Lime = 3 tons -	do.	5.8 2.00 0.6	5.8 1.5 2	4.4 3.4 5	4.2 1.3 50	4.2 1.2 40	4.1 2.7 60	4.2 1.2 30	25
4. Control -	do.	6.2 2.0 0.7	5.6 .4 spoilt	4.0 1.2 7	4.2 1.0 27	4.2 .6 27	4.2 1.6 40	lost	18

"Soil A."—(Contd.)

5. Grass = 20 tons.	do.	6.2 2.0 0.2	4.2 2.6 3	4.1 4.1 4	4.7 1.0 33	4.4 1.6 40	4.0 2.7 60	4.2 1.5 33	21
6. Ammonium sulphate = 4 cwts.	do.	6.2 2.0 0.2	6.4 1.5 2	4.5 3.4 10	4.0 1.5 50	4.0 1.6 52	4.0 3.4 60	4.2 1.4 36	29
7. Urea = 2 cwts.	do.	6.2 2.0 0.6	4.6 1.1 trace	4.1 3.4 14	4.0 1.3 50	4.2 1.3 40	4.0 3.1 80	4.2 8. 31	34
8. Ca. Cyanamide = 4 cwts.	do.	6.2 2.0 0.7	6.2 1.0 trace	4.1 2.6 6.8	4.5 1.4 50	4.4 1.7 47	4.2 2.7 60	4.2 1.0 62	35
9. Ammonium phosphate = 2 cwts.	do.	6.1 2.0 0.2	6.5 2.9 trace	4.0 3.4 8.3	4.2 1.7 50	4.4 1.6 33	4.0 2.8 54	4.2 1.3 31	22
10. Potassium nitrate = 6 cwts.	do.	5.0 2.0 1.5	4.2 1.8 12	4.0 3.5 25	4.0 1.6 125	4.2 2.3 40	4.2 2.5 50	4.0 1.2 37	39

Bulked percolate on 14.12.27 pH=6.2, N as NO₃ 1.4 p.p.m.

TABLE I.

Soil "B."

Pot. No.		30/12/27	6/2/28	9/2	22/3	6/4	13/4	18/5	Average N. as mgs. per litre.
1. Lime = $\frac{1}{4}$ ton per acre -	pH percolate Vol. percolate (litres) N. parts per million as NO_3	4.2 1.5 45	4.2 3.0 60	4.2 9 50	4.2 4.1 2.3 85	4.2 1.3 55	4.0 2.7 50	4.2 1.0 30	51
2. Lime = $\frac{3}{4}$ ton -	do.	4.0 1.6 70	4.2 1.3 40	4.1 2.3 85	4.2 2.2 55	4.2 2.2 55	4.2 2.7 50	4.2 1.6 30	57
3. Lime = 3 tons -	do.	4.0 1.9 50	4.0 3.4 35	4.1 8 90	4.2 2.8 100	4.2 2.1 80	4.2 2.1 80	4.2 6 30	69
4. Control -	do.	4.2 1.8 50	4.4 3.2 30	4.2 7 35	4.2 4.2 35	4.0 1.0 55	4.0 2.7 60	4.2 8 60	47
5. Grass = 20 tons	do.	4.4 4.0 45	4.4 3.6 45	4.2 7 80	4.2 4.2 80	4.2 2.2 55	4.2 3.4 50	4.2 7 40	49

V All percolates pH 4.0 ;
2000 cc N as NO_3 60 p.p.m.

"Soil B." — (Contd.)

6. Ammonium sulphate = 4 cwts.	do.	4.4 1.9 50	4.0 3.4 40	4.2 9 85	4.2 1.4 140	4.2 2.7 100	4.2 7 40	69
7. Urea = 2 cwts.	do.	4.0 4.8 55	4.2 4.2 40	4.2 2.5 85	4.2 2.8 100	4.2 3.4 80	4.2 2.2 65	66
8. Ca. Cyanamide = 4 cwts.	do.	4.0 2.6 50	4.2 3.2 80	4.2 6 170	4.2 1.8 100	4.2 2.9 80	4.2 1.3 60	79
9. Ammonium phosphate = 2 cwts.	do.	4.3 1.5 60	4.2 1.9 40	4.0 2.7 80	4.2 .9 100	4.2 2.8 80	4.2 1.2 35	65
10. Potassium nitrate = 6 cwts.	do.	4.0 1.9 65	4.2 3.2 80	4.1 2.7 60	4.2 1.9 55	4.2 2.6 60	4.2 1.2 35	63

Bulked percolate of 14.12.27 pH=4.7, N as NO₃ 20 p.p.m.

TABLE II.

HISTORY AS IN TABLE I. GRASS PLANTED IN ALTERNATE
POTS 14.6.28.

Soil "A."

Pot No.		12/10	15/10	23/10	9/11	23/11	3/12
1. Bare	pH per- colate N as NO ₃ p.p.m. do	4.5 8	4.5 12	5.7 16	4.7 16	4.2 10	4.5 28
2. Grass planted.	do	6.2 0	6.2 0	6.2 trace	6.2 0.8	6.2 0	6.2 0
3. Bare	do	4.4 13	4.5 18	4.4 18	4.4 16	4.2 12	4.4 12
4. Grass planted.	do	6.0 0	6.2 0	6.2 2	6.4 trace	6.2 0	6.2 1
5. Grass planted.	do	6.2 1	6.2 0	6.2 0	6.2 trace	6.2 0	6.2 1
6. Bare	do	4.2 8	4.2 28	4.4 26	4.2 24	4.2 8	4.4 20
7. Bare	do	4.4 12	4.4 38	4.2 28	4.2 28	4.2 20	4.4 20
8. Grass planted.	do	6.2 0	6.2 0	6.2 trace	6.2 0	6.2 0	6.2 0.5
9. Grass planted.	do	6.4 0	6.2 0	6.2 1	6.2 3	6.2 2	6.2 0
10. Bare	do	4.2 8	4.2 12	4.4 28	4.0 28	4.0 8	6.2 28

TABLE II.

Soil "B."

Pot No.		12/10	15/10	23/10	9/11	23/ 11	3/12
1. Grass planted.	pH per- colate N as NO ₃ p.p.m. do	6.2 0 4.2 30	6.2 0 40	6.2 0 20	6.2 0 30	6.2 0 30	6.2 0 30
3. Grass planted.	do	6.0 trace	0	0	trace	0	trace
4. Bare	do	4.2 45	40	25	55	35	30
5. Grass planted.	do	4.0 40	50	20	55	35	25
6. Bare	do	4.2 30	50	40	55	55	35
7. Grass planted.	do	6.2 trace	0	trace	0	trace	trace
8. Grass planted.	do	6.0 0	trace	trace	trace	trace	
9. Bare	do	4.2 45	55	40	30	35	30
10. Grass planted.	do	6.0 trace	0	trace	trace	0	

TABLE III.

HISTORY AS IN TABLES I AND II. GRASS REMOVED FROM ALL EXCEPT ONE POT (EACH SOIL) ON 14.11.28. SOIL HEAVILY LEACHED FOR 3 DAYS TILL NO_3 IN PERCOLATE WAS NEARLY ZERO. CALAPOGONIUM PLANTED ON 20.11.28, AND ALL POTS WATERED DAILY WITH 300 CCS. DISTILLED WATER THROUGHOUT DRY WEATHER.

Soil "A."

Pot No.	12/3	20/3	26/3	2/4	15/4	18/4	20/4
1. Calapogonium Very good growth ...	6.0 20	5.2 24	5.0 16	6.8 12	6.0 0.7	6.4 trace	6.8 trace
2. Bare ...	6.2 11	6.2 20	7.0 16	6.8 10	6.4 8	6.0 12	6.4 10
3. Calapogonium Very good growth ...	6.4 16	6.1 24	3.7 17	7.0 8	6.8 0	6.8 0	7.2 0
4. Bare ...	6.0 trace	lost	6.0 8	7.0 nil	6.4 0	6.4 0	6.4 2

"Soil A."—(Contd.)

5. Grass	...	do.	6.2 trace	6.4 trace	6.6 trace	6.8 0	7.4 0	6.8 trace	6.8 0
6. Calapogonium Very bad growth	...	do.	5.0 16	5.2 20	5.0 18	5.4 10	5.4 6	4.6 3	4.4 4
7. Calapogonium Bad growth	...	do.	6.1 9	6.0 12	6.2 2	5.4 12	6.0 4	6.2 2	6.4 2
8. Bare	...	do.	6.2 10	6.2 16	5.4 12	7.0 11	7.4 6	6.4 3	4.4 4
9. Bare	...	do.	6.2 12	5.3 28	4.6 17	5.2 24	5.6 12	5.2 8	4.6 8
10. Calapogonium Very bad growth	...	do.	5.7 12	6.4 2	6.0 10	6.4 3	7.0 0.4	7.4 trace	6.4 trace

TABLE III.

Soil "B."

Pot No.		12/3/29	20/3	26/3	2/4	15/4	18/4	23/4	26/4
1. Grass	... pH percolate N as NO ₃ p.p.m.	7.0 trace	6.8 0	6.0 0	6.0 trace	6.4 0	0.4 0	5.4 0	6.0 0
2. Calapogonium Very good growth	... do	6.2 21	5.6 14	5.0 16	6.0 8	6.0 trace	6.2 0	5.0 0	6.0 0
3. Bare	... do	6.3 24	5.6 40	5.7 26	5.6 26	6.2 11	5.6 16	5.0 11	5.6 11
4. Calapogonium Very good growth	... do	5.2 20	5.2 18	5.2 20	5.2 12	5.2 10	6.0 1	6.0 trace	5.6 0

"Soil B."—(Contd.)

5. Calapogonium Very bad growth	...	do	5.2 20	5.5 3	5.0 20	4.4 19	5.0 10	4.6 10	4.4 2	4.6 9
6. Calapogonium Satisfactory growth	...	do	5.4 24	5.4 24	5.2 20	5.0 14	5.4 9	6.0 8	5.6 2	6.0 1
7. Bare	...	do	5.4 14	5.0 17	4.6 20	4.4 18	5.2 10	5.2 12	5.6 10	4.4 11
8. Bare	...	do	6.5 18	5.4 16	4.8 20	5.4 12	6.0 10	5.2 11	4.4 16	4.6 12
9. Calapogonium Bad growth	...	do	6.4 24	5.4 24	4.8 32	5.0 28	5.0 11	4.6 18	4.4 12	lost
10. Bare	...	do	6.0 24	5.2 24	4.6 36	5.0 19	5.0 11	4.6 16	4.6 11	4.6 10

A Rapid Approximate Method of determining the Exchangeable Bases in Non-calcareous Soils

BY

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*Plant Physiologist.**

The majority of inland soils in Malaya are so poor in exchangeable bases that determinations of separate constituents becomes a matter of difficulty, especially in view of the relatively great amounts of aluminium set free by treatment with $N/20$ HCl or NNH_4Cl . In addition these methods like the 'total' methods of Kelley or Bobko-Askinasi are time consuming, and too laborious for routine work, where all that is required is a rough classification of soils into groups of say less than 1, 1—3, 3—6, etc. M.E. of bases per cent.

The electro-dialysis methods are better but scarcely suited to the semi-skilled Assistants of a tropical laboratory.

Recently Kappen** has proposed a rapid method for non-calcareous soils in which the soils are shaken with $N/10$ HCl , and the residual acid titrated back with alkali.

The writer has spent some time in the search for suitable methods, and three were studied in some detail.

- (1) The soil was leached or shaken with ammonium acetate or acetic acid and the leachate or an aliquot of the filtrate, evaporated, ignited, the residue dissolved in an excess of acid and titrated back. Moderately good results were obtained in silver or platinum dishes, but not in those of glass, porcelain or silica. The method was therefore discarded in favour of one which did not involve the use of expensive apparatus.

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** Fort der Landev III p. 1009 '28. Abstracted in Ann. Sc. Agromomigue 46 p. 76 '29 (original not seen).

(2) The soil was treated according to the method of Kappen. Two sources of error were found.

(a) A certain amount of chloride ion was absorbed (or adsorbed) by the soil, and in the case of very poor soils—this may cause an appreciable error. The difficulty can be met by titrating for chlorine.

(b) Many coastal organic soils gave coloured filtrates containing considerable quantities of iron and organic matter which completely upset the titration, giving in many cases a high negative result, i.e. more acid than was added.

(3) The idea was conceived of using an acid aluminium salt to get over the difficulty of 2 (b). The soil was shaken with M/60 AlCl_3 , filtered, and aliquot taken and titrated back using brom-thymol-blue or phenol red as indicator.

The aluminium chloride method was adopted, and on 81 soils has failed twice only to give perfectly clear filtrates.

It suffers from the same disadvantage as the Kappen method, viz. the absorption of chloride and whenever the soil is base-poor, the chloride must be titrated. The writer uses the aliquot already titrated with alkali, adds 1 drop of dilute acetic acid to discharge the colour of the indicator, 3 drops of potassium chromate and titrates in the usual way with silver nitrate.

A theoretical objection to the AlCl_3 method might be that AlCl_3 destroys the base complex without using up Al (or the equivalent H) vide the results of Magistrad* but the comparative figures shown for the AlCl_3 and Bobko-Askinasi methods do not support this, at any rate for the dilution used and for our soils, the results agreeing well within the limits of accuracy defined above.

The agreement found also answers the possible objection that the results of determinations on aliquots cannot be compared with those on leaching.

* Univ. of Arizona Tech. Bull. No. 18, 1928.

METHOD.

20, 10 or 5 grams of soil (depending on richness in bases) is warmed to 50°C with 100 ccs. of $\text{M}/60 \text{ AlCl}_3$ shaken at intervals for half hour, filtered, and 50 ccs. titrated with $\text{N}/10$ soda using phenol red as indicator. If the base content is less than 3 M.E.% the chloride content of the aliquot is then titrated with $\text{N}/10 \text{ AgNO}_3$ using potassium chromate as indicator and the absorption found deducted from the apparent base content.

Kappen has pointed out that the 'total' methods of Kelley and Bobko-Askinasi give results seriously in error if the exchange hydrogen liberated is not taken into account. The annexed table confirms this.

SUMMARY.

A rapid approximate method of determining total bases by the use of $\text{M}/62 \text{ AlCl}_3$ is described.

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TABLE.

Soil	Bases by AlCl_3	Absorption of Cl from AlCl_3	Bases by HCl All figures	Absorption of Cl from HCl are M. E. %	(a) Including exchange H		Bases by Bobko-Askinasi (b) Excluding exchange H.
"Quartzite" Sandy ...	0.8	0.1	1.0	0.1	3.0		0.7
"clay 50% top ...	1.0	1.0	-	-	2.2	-	1.0
" " sub ...	1.1	1.7	-	-	2.4		1.3
"Raub high level" ...	1.0	1.2	1.2	1.8	3.5		1.2
"Granite" ...	0.7	0.2			2.8		0.9
"19 B Rich Coastal clay" ...	9.2	0.3	8.3	0.3	17.5		9.9
"41 B Poor Coastal loam" ...	0.9	0.2	-10.1	0.2	7.6		1.2
"43 B Rich Coastal clay" ...	9.6	0.3	-	-	8.0		8.0

Studies on Tapioca.

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III. FURTHER NOTES ON THE DETERMINATION OF PHOSPHORIC ACID IN TAPIOCA MATERIAL BY THE COERULEO-MOLYBDATE METHOD.

In connection with the investigation of the impoverishment of the soil by tapioca, further determinations¹ of phosphoric acid in various samples of tapioca material and fertilisers have been carried out by the coeruleo-molybdate colorimetric method and the results compared with the molybdate-magnesia gravimetric method.

All the solutions were prepared by thoroughly igniting the material at 700°C, taking up the ash with hydrochloric acid and eliminating silica by repeated evaporation to dryness and baking at 110°C.

Since it has been shown by various workers² that excessive amounts of ferric iron and acid interfered with colour development determinations of these two radicals were also carried out. The proportion of ferric iron was found to be in every case only of the same order or less than the proportion of phosphoric acid. Since the writer had already worked with solutions containing 15 times as much ferric iron as phosphoric acid without appreciably affecting the result it was decided that the iron content could be ignored. Acidity was determined by titrating with standard alkali before dilution. In the process of developing the tint about 1 per cent of sulphuric acid is added as Reagent A so that it seemed unnecessary to neutralize the hydrochloric acid which was present in relatively minute quantities.

Table I shows the amount of phosphoric acid in the various materials as determined by the colorimetric and gravimetric processes, the error calculated on the gravimetric

1. Greenstreet, M.A.J. XVI. 70, 1928.

2. Belgrave. Ibid. XVI. 361, 1928.

TABLE I.

PHOSPHORIC ACID CONTENT OF VARIOUS MATERIALS AND
ACIDITY OF THE TEST SOLUTIONS.

Substance.	Acidity Milligrams HCl in 100 c.c. of test solution.	Phosphoric acid P_2O_5		Error of colorimet- ric deter- mination calculated on gravi- metric det- ermination
		Gravimetric determination	Colorimetric determi- nation	
		per cent.	per cent.	per cent.
Stem C.S.S.	- 1.5			
Tuber C.S.S.	- 1.7	0.094	0.083	- 12
Tuber F2	- 2.5	0.11	0.12	< 10
Tuber E1	- 4.8	0.11	0.12	< 10
Tuber C.M.S.	- 1.5	0.13	0.11	- 15
Stem F2	- 1.3	0.14	0.11	- 21
Tuber J2	- 1.7	D.0.140/0.147	0.15	< 10
Stem J2	- 1.5	0.14	0.13	< 10
Tuber L.K.J.	- ...	0.14	0.14	Nil.
Stem E1	- 3.5	0.15	0.13	- 13
Tuber E2	- 2.0	0.15	0.16	< 10
Tuber F1	- 6.0	D.0.156/0.160	0.16	Nil.
Stem C.M.S.	- 1.7	0.16	0.15	< 10
Stem L.K.J.	- ...	0.17	0.14	- 18
Stem A1	- 0.8	0.17	0.15	- 12
Stem F1	- 0.7	D.0.203/0.250	0.20	Nil.
Tuber G2	- 0.3	0.20	0.19	< 10
Tuber H1	- 0.3	0.20	0.18	- 10
Stem E2	- 0.5	0.21	0.25	+ 19
Stem G2	- 0.7	D.0.240/0.260	0.25	Nil.
Leaf C.S.S.	- 0.2	D.0.332/0.333	0.31	< 10
Leaf K2	- 0.3	0.38	0.36	< 10
Leaf E1	- 0.4	0.42	0.44	< 10
Leaf C.M.S.	- 0.3	0.47	0.52	+ 10
Leaf L.K.J.	- ...	0.48	0.48	Nil.
Leaf F1	- 0.4	0.48	0.48	Nil.
Leaf B1	- 0.6	0.49	0.49	Nil.
Leaf E2	- 0.5	D.0.523/0.528	0.46	- 13
Leaf J2	- 0.4	0.53	0.53	Nil.
Leaf G2	- 0.7	D.0.567/0.577	0.58	< 10
Cattle Manure	- ...	0.62	0.69	+ 11
Superphosphate A	- ...	0.72	0.77	< 10
Superphosphate B	- ...	16.2	17.1	< 10
		16.4	17.2	< 10

D. Denotes duplicate determination.

result (when more than 10 per cent) and the amount of hydrochloric acid in the test solution. A proportion of phosphoric acid of about 1 part in $2\frac{1}{2}$ million was found to be the best concentration for comparing the tints.

Results of analysis indicate there to be no relationship between the acidity of the solutions examined and the error in the determination of phosphoric acid. Out of 33 samples examined, in 13 instances the colorimetric result was lower than the gravimetric, in 12 instances the colorimetric result was higher than the gravimetric, while in 8 instances the results were identical: in only 8 cases did the discrepancy amount to more than 10 per cent. Since all the solutions were prepared similarly there is no evidence to attribute interference with colour development to either iron or acidity.

Comparison of these results with those described in the writer's previous paper shows a marked improvement on the accuracy previously attained. Since identical methods were employed it appears that the increased accuracy is attributable to an increase in skill of manipulating the colorimeter and matching the tints.

It is possible that the further work on the subject which the writer hopes to carry out in the near future may yield still more satisfactory results.

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